SOME DIPLOGRAPTIDS FROM THE BRITISH LOWER SILURIAN

by G. H. PACKHAM

ABSTRACT. Diplograpids (seven species and nine subspecies) are described from various localities in the Lower Silurian of Great Britain, ranging in age from the zone of *Monograptus cyphus* to that of *M. turriculatus*. The study centres about *Glyptograptus tamariscus* (the genotype). From the time of its origin in the zone of *M. cyphus*, *G. tamariscus* displays considerable diversification along a number of different evolutionary lines. Other diplograptids which have some general similarity to *G. tamariscus* are also described, but they appear to be unrelated to it. The new forms described are *Glyptograptus tamariscus distans*, *G. tamariscus varians*, *G. tamariscus angulatus*, *G. tamariscus acutus*, *Climacograptus tamariscoides*, *C. tangshanensis linearis*, *G. enodis enodis*, *G. enodis latus*, *G. elegans* and *C. alternis*.

THE Silurian diplograptids have been largely neglected since the publication of Elles and Wood's *Monograph of British Graptolites*. This neglect is possibly the result of the belief that they are of little stratigraphic value compared with the monograptids, but the work of Davies (1929) did show that there was considerably more variation in diplograptid species on any one horizon and throughout a sequence, than had been expected. The present study endorses Davies's findings.

The material used in this investigation has been drawn principally from the collection of the Sedgwick Museum in Cambridge, supplemented by specimens from the British Museum of Natural History, the University of Birmingham, the University of Aberdeen, and the Geological Survey of Scotland. The fossils described here range in age from the *Monograptus cyphus* Zone to the *M. turriculatus* Zone. The most valuable collections available to me were those from Dobb's Linn, near Moffat in the Southern Uplands of Scotland, and from Rheidol Gorge near Aberystwyth in Wales. The former was made several years ago by the Sedgwick Club; the graptolites here are flattened, or at best, preserved in very low relief; nevertheless, the collection has the advantage of being the most complete stratigraphically, covering all the zones of the Lower Llandovery. The Rheidol Gorge collection was made by Sudbury from the *M. gregarius* Zone at the time she was studying the triangulate monograptids of that zone (Sudbury 1958). All her material is preserved in pyrite in full relief. Other specimens are from the Lake District (Skelgill), the Cross Fell Inlier at Knock, Duffkinnel Burn in the Southern Uplands of Scotland, and isolated localities in Wales.

The identification of some of the graptolite zones in the Dobbs Linn Section has been based on the work of Sudbury (1958) at Rheidol Gorge. The zone of *M. cyphus* is thus the lower division of the zone of *M. gregarius* as Lapworth (1878) recognized it. The base of the zone of *M. gregarius*, thus restricted, is taken as the horizon at which *M. triangulatus* first appears. That part of the zone of *M. gregarius* which is referred to as the lower part in this paper is that containing *M. triangulatus* and lacking *Rastrites*. It corresponds approximately to horizons S (lowest) to H (highest) in the Rheidol Gorge section. *Rastrites* is present in addition to triangulate monograptids in what is referred to here as the upper part of the *M. gregarius* Zone. This latter can be correlated approx-

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imately with horizons from G (lowest) to A (highest) of the Rheidol Gorge Section together with the *Diplograptus magnus* band and the *M. leptotheca* band at the same locality.

Method of study. Since no isolated specimens of the species under investigation are available for study, it has not been possible to determine any details of the development of the proximal portions of the rhabdosomes. Diagnoses of the forms here described thus depend on external morphology. So far as possible, however, special attention has been paid to the proximal end. In the description of thecal form, the term *geniculum* of Jaanusson (1960) has been used to describe the point of maximum flexure of the free ventral wall, the part above it being the supragenicular wall and the part below it the infragenicular wall. Two other conventions used in the description need some explanation. First, the width of the rhabdosome at, say, the fifth thecal pair, denotes the distance from the lip of the aperture of $th5^1$ to that of $th5^2$ measured perpendicular to the axis of the rhabdosome. Secondly, measurements involving the level of the aperture of a theca are taken from the axial extremity of the aperture, rather than the lip. The difference between the axial and lateral levels of the aperture will be noticeably different when the apertures are strongly everted.

In comparing compressed and uncompressed specimens, a geometric approach has been adopted. The cross-sectional profile of specimens preserved in relief is such that assuming simple flattening of the periderm, the width of the graptolite would be increased by about 30 per cent. Unfortunately it has not been possible to check this figure because no compressed and uncompressed specimens of the same form are available from the same locality, but specimens thought to be the same form, from different localities, confirm this assumption. The behaviour of the thecal profile during compression is variable. This is most marked in the infragenicular part of the theca. In specimens preserved in relief, the infragenicular wall varies from approximately planar to distinctly convex in horizontal section. Compression of the planar type could result in the infragenicular wall being folded inwards or outwards, while the convex type will almost certainly be folded outwards. If the infragenicular wall is folded outwards, there will be a tendency for the excavation to be decreased in depth, but this will be counterbalanced by the increase of width resulting from the flattening of the apertural region of the theca below (text-fig. 1*f*). If the infragenicular wall is folded inwards then the depth of the excavation will appear to be considerably greater after compression. This probably applies to *Climacograptus tangshanensis linearis*. For all these reasons little emphasis has been placed on the depth of the excavations.

The specimens preserved in relief are preserved as internal casts in pyrite. The form of this cast is clearly related to the external morphology in a general way, but there is no means of telling whether features like the interthecal septa had any external expression or not, nor whether the periderm was thick or thin. The pyrite has remnants of the periderm adhering to it, but is surrounded by a layer of chloritic mineral, as described by Sudbury (1958).

The text-figures have been prepared originally at a magnification of sixteen on graph paper, the specimen being studied at the same magnification by means of a binocular microscope with a graticule eye-piece.

SYSTEMATIC DESCRIPTIONS

Family DIPLOGRAPTIDAE Lapworth 1873

The species principally under consideration in this paper, *Glyptograptus tamariscus*, is the genotype and thus its morphological characters are of interest in determining the diagnostic features of the genus. The variation of the forms described below does raise some difficulties in nomenclature. The principal difficulty is in distinguishing between *Glyptograptus* and *Climacograptus*, a problem that has been made more difficult by some change in emphasis in the diagnostic features of the two genera by successive authors.

In erecting the genus *Climacograptus*, Hall (1865) drew attention to the thecal shape: 'cellules short and square; apertures apparently excavated in the margin of the stipe, and transversely oval or subquadrate; cell denticles or appendages, if present, usually on the upper side of the aperture'. Lapworth (1873) distinguished between *Climacograptus* and *Diplograptus* on the basis of the inclination of the thecae and the location of ornamental spines (if any), *Climacograptus* having 'thecae perpendicular: without ornament, or furnished proximally with a single, median, marginal spine. Polypary tapering; section circular or bilobate. Thecae free, section sub-oval.' *Diplograptus* has 'thecae inclined: without ornament, or furnished distally with two lateral apertural spines'. The sub-genus *Glyptograptus* was further distinguished by having the 'polypary usually styliform, section concavo-convex. Thecae usually free, section sub-oval.'

Elles and Wood (1906) shifted the emphasis to the degree of sigmoidal curvature of the thecal wall, and the disposition of the aperture. Their description of *Climacograptus* is: 'Thecae tubular, ventral walls with every degree of sigmoidal curvature; apertural margins typically horizontal situated within well-defined "excavations", occasionally introverted and rarely introtorted'. They describe the thecae of *Diplograptus* as 'subprismatic or sub-cylindrical tubes, ventral walls typically inclined and more or less straight; apertural margins even or undulated'. They also say (1907, p. 218) 'in the typical forms of the sub-genus *Glyptograptus* the theca is shorter and stouter [than in other sub-genera of *Diplograptus*], and the middle third of its ventral wall impressed to form a distinct "excavation" as in the genus *Climacograptus;* but the free edge is inclined instead of being vertical, the sigmoid ventral curve is flowing rather than sharp, and the "excavation" is wide instead of deep'. Elles and Wood also distinguish between different cross-sections of the rhabdosomes.

Subsequent definitions have been based on essentially the same characters as recognized by Elles and Wood. The problem of assigning difficult species to one genus rather than the other was recognized by Ruedemann (1904) and later implied by Elles (1922) when she wrote '?*Glyptograptus*' alongside several species of *Climacograptus* in the table accompanying that paper. More recently Jaanusson (1960) said that 'the morphological line from the orthograptid type to the climacograptid type is well documented. There exist all possible transitions between these extremes.' From this premiss he goes on to including the Climacograptinae in the Diplograptinae 'on account of the present difficulties in defining the former taxon.'

The difficulty of generic determination is apparent in species of British climacograptids, for example *C. scalaris miserabilis*, *C. wilsoni*, and *C. brevis*. In the first two cases

the supragenicular wall is vertical, but the geniculum is not so sharp as other species of the genus. The infragenicular wall is thus inclined at a relatively small angle (*c.* 45°) to the length of the rhabdosome. In *C. wilsoni* the proximal thecae at least are considerably inclined to the rhabdosome length and the geniculum is again not very sharp. Of the British species of *Glyptograptus* defined by Elles and Wood (1906, 1907), the only forms which present any real difficulty are *G. tamariscus* and possibly *G. teretiusculus siccatus*. Examination of the figures of *G. tamariscus* in Elles and Wood (1907) reveals the diversity of form of the thecae. The supragenicular walls vary from vertical (fig. 167*a*) to gently inclined (fig. 167*d*) and the geniculum from smooth and gentle (fig. 167*d*) to distinctly angular (some of the thecae of fig. 8*c*, plate xxx). The specimens examined in this study show a similar variation.

In this paper I have distinguished forms as *Climacograptus* which have an abrupt geniculum, with the infragenicular wall just beneath the geniculum inclined at an angle of at least 45 degrees to the rhabdosome length. The supragenicular wall in these forms is approximately parallel to the sides of the rhabdosome. This is not in any way an attempt to define the difference between the two genera; it is simply a rule of convenience for present purposes. At present it is probably best to regard the two genera as 'form genera' until far more isolated material becomes available.

The forms described here are divided into two groups: (*a*) narrow forms and (*b*) wider forms.

(*a*) *Narrow forms*

Genus GLYPTOGRAPTUS Lapworth 1873

Glyptograptus tamariscus (Nicholson)

Plate 71, figs. 1–4, 7–17; Plate 72, fig. 8; text-figs. 1*a-v*, 3*a-d*

1868 *Diplograpsus tamariscus* Nicholson, p. 526, pl. 19, fig. 12 (*non* figs. 10, 11, 13).
1872 *Diplograptus tamariscus* Nicholson; Nicholson, p. 117, text-fig. 4*c*.
?1876 *Diplograptus tamariscus* Nicholson; Lapworth, pl. 24, fig. 134.
?1877 *Diplograptus tamariscus* Nicholson; Lapworth, pl. 6, fig. 12.
?1897 *Diplograptus tamariscus* Nicholson; Perner, p. 4. pl. 9, fig. 16.
?1897 *Diplograptus tamariscus* Nicholson; Törnquist, p. 15, pl. 2, figs. 15–19.
1907 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Elles and Wood (*pars*), p. 247, pl. 30, fig. 8*d* (*non* text-figs. 164*a-d*, pl. 30, figs. 8*a-c*).
1920 *Diplograptus tamariscus* Nicholson; Gortani, p. 17, pl. 1, figs. 22, 23.
?1920 *Diplograptus tamariscus incertus* Elles and Wood; Gortani (*pars*), p. 18, pl. 1, figs. 25, 26 (*non* figs. 24, 27).
?1920 *Diplograptus tamariscus laxus* Gortani, p. 19, pl. 1, fig. 28.
1931*a* *Diplograptus* (*Glyptograptus*) cf. *tamariscus* Nicholson; Haberfelner, p. 104, pl. 3, fig. 16.
1934 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Hsü, p. 76, text-figs. 26*a*, *b*, pl. 6, figs. 1*a-f*.
1949 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Harris and Thomas, p. 54, figs. 13-14*a*.
1954 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Sherrard, p. 98, pl. 11, fig. 19.
Note. The above can only be referred to *G. tamariscus* s.l.
non 1927 *Glyptograptus* aff. *tamariscus* (Nicholson); Whittard, p. 469, text-figs. A-C, pl. 13, 14.
non 1931*b* *Diplograptus* cf. *tamariscus* Nicholson; Haberfelner, p. 47, pl. 1, fig. 8.

Lectotype. Nicholson (1868) did not select a type specimen when he described the species, but subsequently Přibyl (1948) selected fig. 10 of plate 19 of Nicholson (1868) as the lectotype. The specimen probably corresponding to this figure has been located in the collection of the British Museum of

Natural History (BM (NH) 24925) and is figured here as text-fig. 1*q* and Plate 71, fig. 13. This specimen is flattened and incomplete; it is a young colony the proximal tip of which is missing. Přibyl's lectotype comes from Duffkinnel Burn, near Wamphray, in southern Scotland, as does this specimen. The horizon cannot be determined with any accuracy because all of the zones from *Akidograptus acuminatus* to *Monograptus turriculatus* are apparently present in that stream (judging from the fauna listed by Peach and Horne in 1899).

Horizon. Specimens of all the various varieties described below range from the *M. cyphus* Zone to the *M. turriculatus* Zone.

Revised diagnosis. Narrow rhabdosome, reaching possibly 2 mm. in width in the widest forms, thecae alternating with small overlap, excavations occupying approximately half the width of the rhabdosome, apertures horizontal or everted, supragenicular wall near perpendicular and longer than the length of the excavation, geniculum more or less rounded, median septum absent from the reverse side of the rhabdosome.

Description. There is considerable variation in the length of the rhabdosomes of specimens of this species, the shortest being several millimetres and the longest being over 4 centimetres. The width of the broadest forms may reach 2 mm. The rhabdosome is either parallel-sided or gently tapering.

The thecae vary considerably in spacing, from about seven to approximately fourteen per centimetre. The thecal shape is likewise very variable, but in all forms of the species, the thecae are moderately to strongly sigmoidally curved with the supragenicular wall more or less perpendicular. The interthecal spacing (measured between one aperture and the next in the same series) is almost constant throughout any rhabdosome except at the proximal end where the first and second thecae in each series are sometimes a little closer than succeeding thecae.

The depth of the excavations increases along the rhabdosome so that as the rhabdosome widens they occupy about the same proportion (about one-half) of the width throughout. They occupy less than half the margin of the rhabdosome, measuring them from the lip of the aperture to the geniculum of the theca above.

In specimens preserved in relief the septum is absent from the reverse side; in flattened

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TEXT-FIG. 1. *a-f. Glyptograptus tamariscus varians* subsp. nov. *a*, Obverse of specimen in relief SM. A24925. *b*, Reverse of same specimen. *c*, Reverse of flattened specimen, SM. A51430. *d*, Holotype, reverse of specimen in relief, SM. A51439. *e*, Reverse of flattened specimen, SM. A51437. *f*, Reverse of flattened specimen, SM. A51435.

g-j, G. tamariscus tamariscus (Nicholson), form A. *g*, Reverse of flattened specimen, SM. A51412. *h*, Reverse of specimen in relief, SM. A24934. *i*, Obverse of same specimen. *j*, Reverse of flattened specimen, SM. A51417.

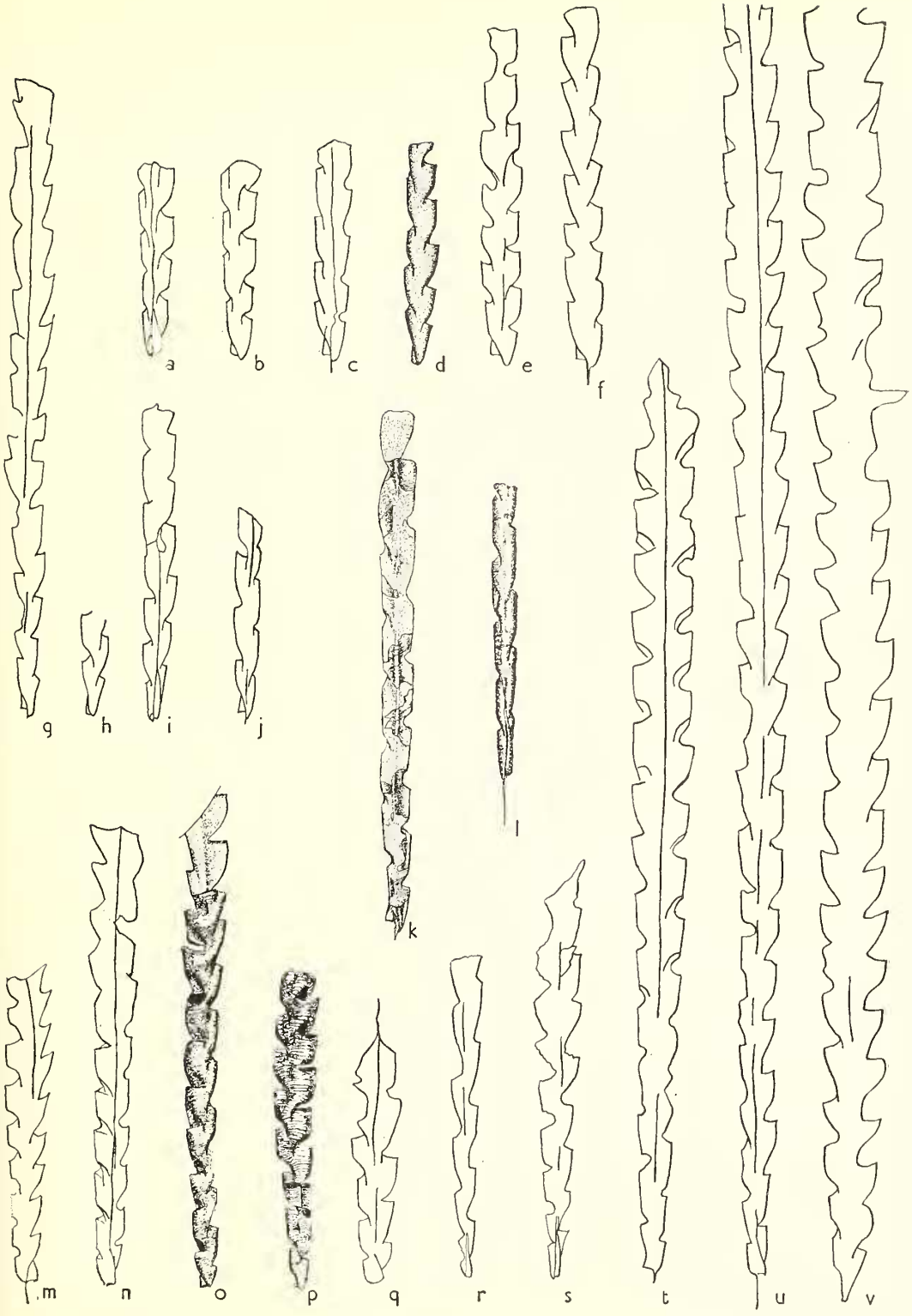
k-l. G. tamariscus distans subsp. nov. *k*, Reverse of flattened specimen, SM. A51428. *l*, Holotype, obverse of specimen in relief, SM. A24942.

m-p. G. tamariscus tamariscus (Nicholson), form B. *m*, Impression of reverse of flattened specimen, SM. A51419. *n*, Obverse of flattened specimen, SM. A51418. *o*, Reverse of specimen in half relief, SM. A20383. *p*. Reverse of specimen in half relief, SM. A51421.

q-u. G. tamariscus tamariscus (Nicholson), form C, *q*, Possible holotype, obverse of flattened specimen, BM (NH) 24953. *r*, Obverse of flattened specimen, SM. A51425. *s*, Obverse of flattened specimen, SM. A51424. *t*, Reverse of flattened specimen, Scot. Survey 5619. *u*, Proximal part of flattened specimen, SM. A51003.

v. G. tamariscus linearis Perner. Reverse, flattened specimen, BU. 1272.

All figures ×7·5. Horizons and localities given in text.



TEXT-FIG. 1

specimens, there is some evidence of the septum, but this is probably a result of compression. In all the flattened specimens the periderm is thin—much thinner than in, say, *G. incertus* in the same band. Half-rings are distinctly visible in some specimens, notably those from Skelgill in half relief. Although it is not possible in the specimens available to count the half-rings precisely, it can be said that they are more closely spaced and more numerous in the proximal than the distal thecae. The sicula is normally a little over a millimetre long and exposed throughout its length.

Remarks. In this paper a number of subspecies are described; they are *G. tamariscus tamariscus* (Nicholson), *G. tamariscus linearis* Perner, *G. tamariscus distans* nov., *G. tamariscus angulatus* nov., *G. tamariscus acutus* nov., and *G. tamariscus varians* nov. Wide forms assigned to this species have been reported from central Europe (Münch, 1952) and Sardinia (Gortani, 1922). The Chinese species *Glyptograptus luushanensis* Hsü (1934) might include these forms.

The graptolite described as *Glyptograptus* aff. *tamariscus* by Whittard (1927) has not been included in *G. tamariscus* in this paper because of the presence of a complete septum and the strongly climacograptid aspect of the thecae.

The form described by Haberfelner (1931*b*) as *G.* cf. *tamariscus* has glyptograptid thecae at the proximal end, and orthograptid thecae at the distal end, and for that reason has been excluded from *G. tamariscus* in this paper. It may, however, be related to *G. elegans* sp. nov. described later.

Glyptograptus tamariscus tamariscus (Nicholson)

Plate 71, figs. 1–4, 11, 13; text-figs. 1*g-j*, *m-u*

1868 *Diplograpsus tamariscus* Nicholson, p. 526, pl. 19, figs. 10, 11, 13 (*non* fig. 12).
?1897 *Diplograptus tamariscus* Nicholson; Perner, p. 4 pl. 9, fig. 16.
1907 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Elles and Wood, pl. 247, text-figs. 167*a-c*, pl. 30, fig. 8*a* (*non* text-fig. 167*d*, pl. 30, fig. 8*b-d*).

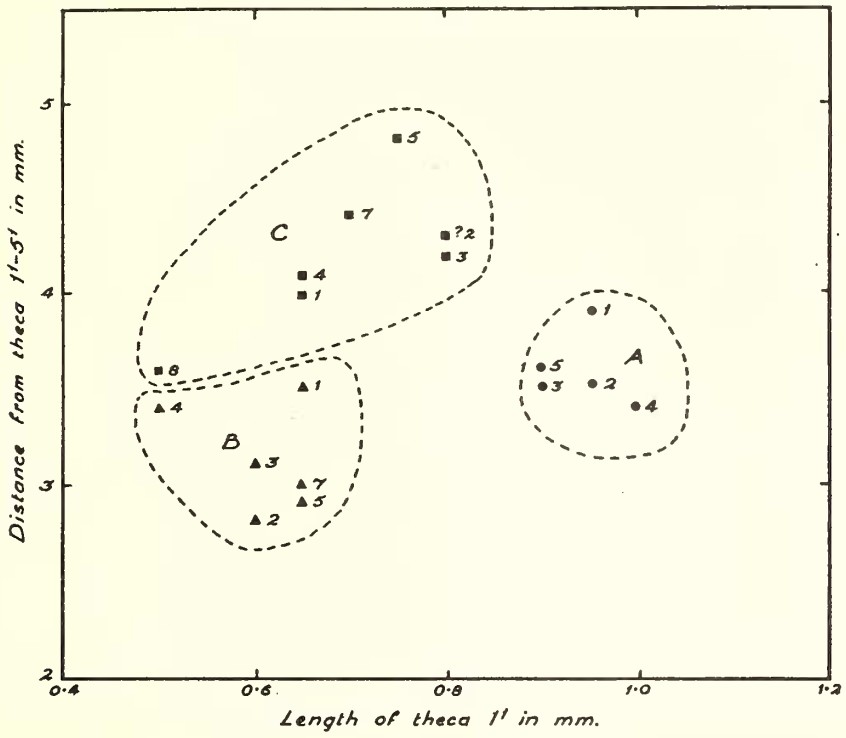
Lectotype. Nicholson (1868), plate 19 fig. 10, was selected by Přibyl (1948) as lectotype. The corresponding specimen is probably BM (NH) 24953 in the British Museum of Natural History. It is figured here as text-fig. 1*q* and Plate 71, fig. 13.

Horizons and localities. The specimens studied range from the base of the zone of *Monograptus cyphus* to the lower part of the zone of *M. turriculatus.* Dobb's Linn: base of the zone of *M. cyphus* (SM. A51411), near top of the zone of *M. cyphus* (SM. A51412), lower part of the zone of *M. gregarius* (SM. A51413, SM. A51414), upper part of the zone of *M. gregarius* (SM. A51417), band of *Cephalograptus cometa* (SM. A51418, SM. A51003, SM. A51422, SM. A51423, SM. A51424, SM. A51425, SM. A51426), lower part of the zone of *M. sedgwicki* (SM. A51419). Duffkinnel: zone of *M. convolutus* (Scotland Survey 5619) and BM (NH) 24953 (horizon unknown). Skellgill: zone of *M. fimbriatus* (SM. A20382), zone of *M. argenteus* (SM. A51421), zone of *M. convolutus* (SM. A20383, SM. A22487). Knock: low in the zone of *M. turriculatus* immediately downstream from the smash belt between the Ashgill shales and the Browgill beds on Swindale Beck, the bed contains a fauna similar to that recorded by Shotton (1935) at his locality c, but is stratigraphically below it (SM. A51420). Rheidol Gorge: zone of *M. gregarius*, horizon H (SM. A24934).

Revised diagnosis. Tapering form of *G. tamariscus* reaching 1·3 mm. in flattened specimens, theca 1^1 has its aperture between 0·5 and 1·0 mm. from the proximal end of the rhabdosome. Thecal excavations deep and relatively long.

Description. This subspecies is variable and within it three ill-defined forms can be recognized. These forms have some stratigraphic significance, so their separation is of some value. The principal dimensions of selected specimens are quoted in the table and some of these are plotted in text-fig. 2.

Throughout the group, the wider specimens have their thecae more closely spaced suggesting that the volume of the theca might be roughly constant.



TEXT-FIG. 2. The three forms of *Glyptograptus tamariscus tamariscus* Nicholson. The numbers correspond to those in the table in the text.

In form A the supragenicular wall is slightly inclined to the vertical, the excavations are deep and the apertures are horizontal to slightly everted. Form B appears to have been more circular in cross-section since all the specimens are preserved in a position slightly removed from the biprofile view. This peculiar mode of flattening may have been enhanced by a greater strength of the median septum resulting in twisting on compression so that the apertures on one series of thecae are more or less facing the observer. The thecae are more closely spaced than in the other two forms. Form C resembles form A in general features but the thecae are more distant and the first theca is shorter.

Sufficient of the probable type specimen is preserved to be able to identify it with form C. Other specimens of this form from the same locality are rather broader than the specimens of the same form from Dobb's Linn and text-fig. 1*u* is more typical of the broader specimens.

Dimensions (in millimetres)

Specimen Number	Flat or relief	Length of rhabdosome	Width th1	Width th5	Width maximum	Length th1[1]	Length th1[2]	Sicula	th5[1] to th1[1]	Th/cm. th1–2	Th/cm. th4–5
Form A											
1. SM. A51411	F	4·7	0·5	0·85	0·85	0·95	1·25	..	3·9	13	10
2. SM. A51412	F	13	0·5	0.8	0·9	0·95	1·2	..	3·5	13	*c.*10
3. SM. A51413	F	13	0·5	0·8	1·1	0·9	1·5	?0·95	3·5	13	*c.*10
4. SM. A51414	F	11	0·5	0·9	1·1	1·0	?1·5	..	3·4	13	*c.*10
5. SM. A24934	R	6·5	0·5	0·6	0·65	0·95	1·35	1·25	3·6	*c.*12	*c.* 9
6. SM. A51417	F	4·5	0·4	..	?0·5	0·9	1·3	..	..	12	..
Form B											
1. SM. A51418	F	9·5	0·5	0·7	1·1	0·65	0·75	1·0	3·5	13	*c.*11½
2. SM. A51419	F	6·5	0·5	0·9	1·0	0·65	1·0	..	2·8	14	*c.*12
3. SM. A20382	½R	6·0	0·4	0·7	0·75	0·65	0·95	..	3·1	14	12
4. SM. A20383	½R	10·0	0·45	0·6	0·9	0·5	0·7	..	3·4	13	10
5. SM. A22478	½R	7·5	0·4	0·75	0·9	0·65	0·95	0·95	2·9	15	12½
6. SM. A51420	F	11·0	0·45	..	0·9	0·85	1·15	..	..	14	12
7. SM. A51421	½R	6·5	0·4	0·8	0·9	0·65	0·85	..	3·0	13	12
Form C											
1. SM. A51003	F	43	0·4	0·8	1·2	0·65	1·1	?0.9	4·1	10	9
2. SM. A51422	F	12	0·45	0·75	0·9	?0.8	?1·1	?0·9	?3·8	..	9
3. SM. A51423	F	10	0·4	0·7	0·8	0·8	1·2	..	4·2	13	10
4. SM. A51424	F	8	0·45	0·75	1·0	0·65	1·0	?0·9	3·6	13	*c.*10
5. SM. A51425	F	8	0·35	0·6	0·7	0·75	1·25	1·0	4·8	10	7
6. SM. A51426	F	12	0·4	0·55	0·8	..	..	..	4·4	..	8
7. Scot. Sur. H1615	F	18	0·5	0·9	1·3	0·7	1·0	..	4·4	11	9
8. BM (NH) 24953	F	5·5	0·6	?1·1	?1·1	0·5+	0·85+	..	3·6	12	*c.* 9

Remarks. The other two long subspecies of *G. tamariscus* are *G. tamariscus linearis* and *G. tamariscus distans*. Both are essentially parallel-sided, but *G. tamariscus linearis* is rather broader than *G. tamariscus tamariscus*, tapering suddenly in the proximal end. *G. tamariscus distans* has smaller excavations and longer supragenicular walls than the typical form.

Glyptograptus tamariscus linearis Perner

Plate 72, fig. 8; text-fig. 1*v*

?1868 *Diplograpsus tamariscus* Nicholson, p. 526, pl. 19, fig. 13 (*non* figs. 10–12).
?1876 *Diplograptus tamariscus* Nicholson; Lapworth, pl. 2, fig. 34.
?1877 *Diplograptus tamariscus* Nicholson; Lapworth, pl. 6, fig. 12.
?1897 *Diplograptus tamariscus* Nicholson; Törnquist, p. 15, pl. 11, figs. 15–19.
1897 *Diplograptus tamariscus linearis* Perner, p. 4, text-fig. 2 (? pl. 9, fig. 23).
1907 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Elles and Wood (*pars*), p. 247, pl. 30, fig. 8*c* (*non* text-figs. 167*a-d*, pl. 30, figs. *a*, *b*, *d*).

Lectotype. Specimen figured by Perner (1897) as *G. tamariscus linearis* (text-fig. 2) was designated lectotype by Přibyl (1948); it is from the zone of *Monograptus convolutus*.

Number of specimens. One (the specimen figured by Elles and Wood, pl. 30, fig. 8*c*). Birmingham Univ. 1272.

Horizon and locality. Dobb's Linn. Probably the zone of *M. cyphus* (*Orthograptus mutabilis*, cf. *Dimorphograptus decussatus* and monograptid fragments on the same slab).

Revised diagnosis. Long, broad, parallel-sided, width almost constant beyond the first few millimetres, excavations deep.

Description. The only specimen available is preserved flattened, it has a length of 34·5 mm. and reaches a maximum width of 1·5 mm. The rhabdosome is slightly tapering, but is essentially parallel-sided. The width at the first pair of thecae is 0·7 mm. and at the fifth pair of thecae 1·25 mm. The thecae are spaced at the rate of eleven thecae per centimetre decreasing distally to nine per centimetre. The excavations are deep and occupy slightly more than half of the width of the rhabdosome and about half the margin of the rhabdosome. The geniculum is rounded and the supragenicular wall is inclined to the rhabdosome length. The apertures appear to be approximately horizontal. The overlap is apparently very small. Some trace of the septum can be seen although the view preserved is the reverse; this is apparently the result of intense flattening. The proximal end is damaged, so that the lengths of the first thecae cannot be determined with any accuracy, but the aperture of th1[1] is at least 1 mm. above the proximal end of the rhabdosome.

Dimensions (in millimetres)

Specimen Number	Flat or relief	Length of rhabdosome	Width			Length		Sicula	th5[1] to th1[1]	Th/cm.	
			th1	th5	maximum	th1[1]	th1[2]			.... th1–2	..... th4–5
B.U. 1272	F	34·5	0·7	1·5	1·5	1·0+	1·4+	..	3·8	11	c.9

Remarks. This is the largest form of *G. tamariscus* in this collection. It differs from the other forms in the distinct inclination of the thecae, in which respect it resembles *G. serratus*, but *G. serratus* is a much larger and coarser species. The specimen of *G. tamariscus linearis* described here is from a horizon considerably lower than the one at which the form occurs in Bohemia, the zone of *Demirastrites convolutus* (Přibyl 1948). Other distinguishing features have been mentioned above (see *G. tamariscus tamariscus*).

Glyptograptus tamariscus distans subsp. nov.

Plate 71, figs. 9–10; text-figs. 1*k-l*

Holotype. The specimen figured as text-fig. 1*l* and Plate 71 fig. 9, from F horizon (Sudbury 1958) of the *Monograptus gregarius* zone, Rheidol Gorge, near Aberystwyth, SM. A24942.

Number of specimens. Two.

Horizons and localities. Approximately the base of the zone of *Monograptus cyphus* at Dobb's Linn (SM. A51428) and the *Monograptus gregarius* Zone (F horizon) at Rheidol Gorge.

Diagnosis. Narrow form of *G. tamariscus* (0·8 mm. flattened), parallel-sided, interapertural distance a little over a millimetre, thecal excavations narrow, supragenicular wall long and perpendicular.

Description. Both specimens have a preserved length of approximately 10 mm. (the holotype is preserved partly as a cast). The width at th1[1] is 0·5 mm. in the flattened specimen and 0·4 mm. in the specimen in relief. Both specimens are almost parallel-sided distally to the first pair of apertures and tapered proximally to them. The base

of th1[1] extends about 0·1 mm. below the aperture of the sicula and proximal to it is a stout virgella. The flattened specimen from Dobb's Linn shows the reverse view so that the length of the sicula cannot be determined, but it is visible for 0·45 mm. before being obscured by th1[2]. In the Rheidol Gorge specimen the sicula is apparently exposed for its entire length (1·4 mm.) extending upwards to a little above the aperture of th1[2]. There are eight or nine thecae per centimetre at the proximal end, decreasing to about seven per centimetre by the fifth pair of thecae.

The supragenicular walls are straight and parallel to the sides of the rhabdosome, averaging 0·8 mm. long. The excavations are shallow, occupying less than half of the width of the stipe even in the flattened specimen. The excavation has an average length of 0·3 mm. being somewhat less for the first couple of thecae. The sigmoidal curvature of the thecae is gentle and the thecal overlap is of the order of a quarter of the thecal length. The apertures are everted. The septum is developed only on the obverse side.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5[1] to th1[1]*	*Th/cm.*	
			th1	*th5*	*maximum*	*th1[1]*	*th1[2]*			*th1–2*	*th4–5*
SM. A51428	F	11	0·5	0·65	0·8	1·0	1·4	..	4·9	8	7
SM. A24942	R	10	0·4	0·5	0·5	1·05	1·5	1·4	4·9	9	7½

EXPLANATION OF PLATE 71

All figures except fig. 13, ×7·5. Horizons and localities given in text.

Fig. 1. *Glyptograptus tamariscus tamariscus* (Nicholson), form B; SM. A20383, reverse of specimen in half relief.

Figs. 2–3. *Glyptograptus tamariscus tamariscus* (Nicholson) form A. 2, SM. A24934, reverse of specimen in relief. 3, obverse of same specimen.

Fig. 4. *Glyptograptus tamariscus tamariscus* (Nicholson), form B; SM. A51421, reverse of specimen in half relief.

Fig. 5. *Glyptograptus sp.* cf. *G. tamariscus fastigans* (Haberfelner); SM. A51443, impression of reverse of flattened specimen.

Fig. 6. *Climacograptus tamariscoides* sp. nov. SM. A24924, obverse of specimen in relief.

Figs. 7–8. *Glyptograptus tamariscus angulatus* subsp. nov. 7, SM. A51440, obverse of specimen in relief. 8, SM. A24926, holotype, reverse of specimen in relief.

Figs. 9–10. *Glyptograptus tamariscus distans* subsp. nov. 9, SM. A24924, holotype, obverse of specimen in relief. 10, SM. A51428, reverse of flattened specimen.

Fig. 11. *Glyptograptus tamariscus* (Nicholson), form C. SM. A51003, proximal part of long flattened specimen.

Fig. 12. *Glyptograptus tamariscus acutus;* SM. A24952, reverse of specimen in relief.

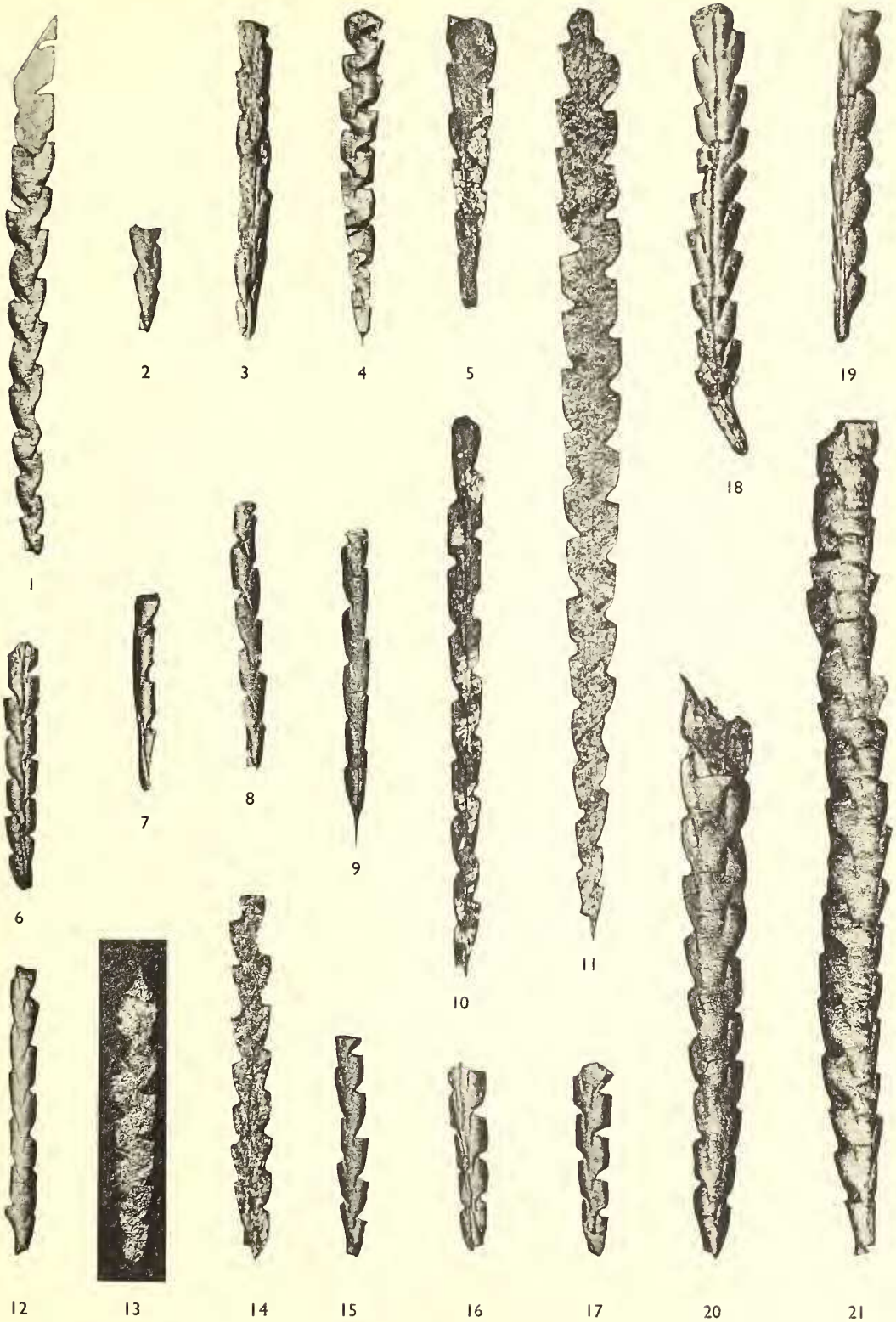
Fig. 13. *Glyptograptus tamariscus tamariscus* (Nicholson), form C. BM (NH) 24953, possible holotype, obverse of flattened specimen, ×8·75.

Figs. 14–17. *Glyptograptus tamariscus varians* subsp. nov. 14, SM. A51435, reverse of flattened specimen. 15, SM. A51439, holotype reverse of specimen in relief. 16, SM. A24925, obverse of specimen in relief. 17, reverse of same specimen.

Figs. 18–19. *Glyptograptus enodis enodis* subsp. nov. 18, SM. A24973, holotype, obverse in relief. 19, SM. A51450, obverse in relief.

Fig. 20. *Glyptograptus enodis latus* subsp. nov. SM. A24967, holotype, reverse in relief.

Fig. 21. *Glyptograptus enodis enodis* subsp. nov. SM. A51453, reverse of specimen in relief.



PACKHAM, Lower Silurian diplograptids

Remarks. In size and general form *G. tamariscus distans* is closest to *G. tamariscus angulatus*, but differs from it in having a much shallower and shorter excavation. *G. tamariscus angulatus* also has a more abrupt geniculation.

Glyptograptus tamariscus varians subsp. nov.

Plate 71, figs. 14–17; text-figs. 1*a-f*

Holotype. The specimen figured as text-fig. 1*d* and Plate 71, fig. 5, from C horizon (Sudbury 1958) of the *Monograptus gregarius* Zone, Rheidol Gorge, near Aberystwyth, SM. A51439.

Number of specimens. Twelve.

Horizons and localities. Dobb's Linn; low in the zone of *M. cyphus* (SM. A51429, SM. A51430), middle of the same Zone (SM. A51431, SM. A51432), top of the zone (SM. A51434, SM. A51435), lower part of the *M. gregarius* zone (SM. A51436, SM. A51437). Rheidol Gorge: zone of *M. gregarius*, horizon D (SM. A51738), horizon C (SM. A24925, SM. A24927, SM. A51439).

Diagnosis. Short narrow form of *Glyptograptus tamariscus* reaching maximum width by at least the third pair of thecae and thereafter parallel-sided or decreasing in width, geniculum becoming more gentle distally.

Description. The longest specimen is 8 mm. in length. The width of the rhabdosome is approximately uniform throughout the length or narrows distally. The widest specimen reaches a maximum width of 1·1 mm. Accompanying the tendency for the rhabdosome to narrow distally there is a change in the thecal shape; distally the geniculum is rounder and the excavation a little deeper, giving the thecae a more gentle sigmoidal curvature. The proximal end of the rhabdosome is robust and th1[1] varies in length between 0·75 and 1·15 mm. The sicula has between 1·0 and 1·4 mm. of its length visible on the obverse side, this could be as high as 1·6 mm. in one specimen. Thecae are at the rate of eleven to fourteen per centimetre at first, decreasing somewhat in most specimens towards the distal end.

Dimensions (in millimetres)

Specimen Number	Flat or relief	Length of rhabdosome	Width			Length		Sicula	th5[1] to th1[1]	Th/cm.	
			th1	th5	maximum	th1[1]	th1[2]			th1–2	th4–5
SM. A51430	F	4	0·65	0.7	0·7	0·95	1·2	..	3·6	12½	10½
SM. A51429	F	6·5	0·65	*c.*1·0	1·0*	0·90	1·15	..	3·0	14	10½
SM. A51431	F	8	1·0	0·95	1·1 (th2)	1·1	1·6	?1·6	3·0	13	12
SM. A51432	F	7	0·7	0·75	0·8	1·15	1·5	1·4	3·2	13	11
SM. A51434	F	5	0·65	0·8	0·8	0·95	1·15	..	3·0	13	13
SM. A51435	F	7	0·7	0·75	0·8 (th3)	0·95	1·5	..	3·3	12	10½
SM. A51436	F	6	0·7	0·75	0·9	1·1	1·6	?1·0	3·3	14	11
SM. A51437	F	6·5	0·7	0·85	0·85	0·75	1·35	..	3·5	11½	10½
SM. A51438	R	4·3	0·6	0·6†	0·7	?0·9	1·2	..	3·4†	12	11†
SM. A51439	R	4·5	0·55	0·6	0•65	0·9	1·2	..	3·5	12½	11½
SM. A24925	R	4·1	0·55	0·8	0·80	0·85	1·25	1·0	3·2†	12½	*c.*10
SM. A24927	R	2·5	0·45	..	0·55	?1·0	1·4	?1·4	..	12	..

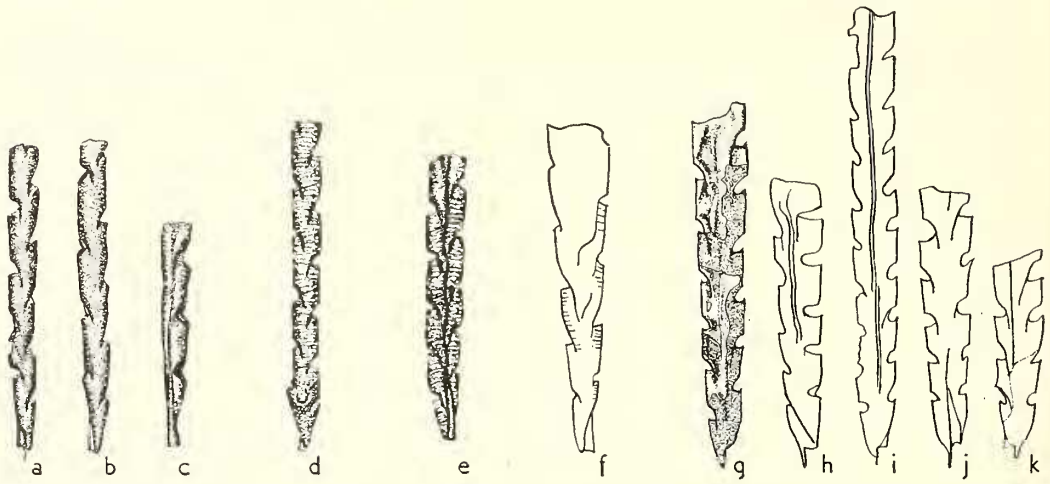
* Specimen preserved in twisted position. † Extrapolated.

Remarks. The parallel-sided nature of the rhabdosome with its relatively robust proximal end distinguishes this form from all others. It is shorter and more robust than *Glyptograptus tamariscus tamariscus*, its thecae are more closely spaced than *G. tamariscus distans* and it is a broader form than *G. tamariscus angulatus*.

Glyptograptus tamariscus angulatus subsp. nov.

Plate 71, figs. 7–8; text-figs. 3*a-c*

Holotype. The specimen figured as text-fig. 3*b* and Plate 71, fig. 8, from horizon C (Sudbury 1958) of the zone of *Monograptus gregarius* from Rheidol Gorge near Aberystwyth, SM. A24926.



TEXT-FIG. 3. *a-c. Glyptograptus tamariscus angulatus* subsp. nov. *a*, Reverse of specimen in relief, SM. A24976. *b*, Holotype, reverse of specimen in relief, SM. A24926. *c*, Obverse of specimen in relief, SM. A51440.

d, G. tamariscus acutus. Reverse of specimen in relief, SM. A24952.

e, Climacograptus tamariscoides sp. nov. Holotype, obverse of specimen in relief. SM. A24924.

f, Glyptograptus sp. cf. *G. tamariscus fastigans* Haberfelner. Impression of reverse of flattened specimen, SM. A51443.

g-k. Climacograptus tangshaneusis linearis subsp. nov. *g*, Holotype, obverse of flattened specimen, SM. A51448. *h*, Obverse of flattened specimen, SM. A51446. *i*, Impression of reverse of flattened specimen, SM. A51444. *j*, Obverse of flattened specimen, SM. A51449. *k*, Reverse of flattened specimen, SM. A51447.

All figures ×7·5. Horizons and localities given in text.

Number of specimens. Five.

Horizons and localities. Dobb's Linn; near the top of the zone of *M. cyphus* (SM. A51441). Rheidol Gorge; at the top of the *M. cyphus* Zone (SM. A24976) from horizon T, and the *M. gregarius* Zone, horizon G (SM. A51441) and horizon C (SM. A24926, SM. A51442).

Diagnosis. Narrow, short form, parallel-sided, geniculum relatively abrupt, supragenicular wall long and perpendicular, thecal excavation deep.

Description. The length of the longest specimen of this form is 7 mm. and the width of specimens preserved in relief at the first pair of thecae is 0·4 mm. and 0·5 mm. in the

flattened specimen (Dobb's Linn), distally the form widens slightly, but proximally it tapers evenly to a pointed proximal extremity. The base of th1[1] extends slightly below the aperture of the sicula and there is a short virgella.

The supragenicular walls are straight and parallel to the sides of the rhabdosome averaging 0·7 mm. in length. The geniculum is abrupt rather than flowing, but not angular. The infragenicular wall is moderately to slightly concave longitudinally and planar transversely. The excavations occupy approximately half the width of the rhabdosome in specimens preserved in relief. The apertures are everted, the overlap of the thecae is less than a third. There are between 9 and 11½ thecae per centimetre initially, decreasing distally.

Dimensions (in millimetres)

Specimen Number	Flat or relief	Length of rhabdosome	Width			Length		Sicula	th5[1] to th1[1]	Th/cm.	
			th1	th5	maximum	th1[1]	th1[2]			th1–2	th4–5
SM. A24976	R	5·5	0·4	0·5	0·5	0·95	1·4	..	3·9	11½	10½
SM. A24926	R	5·6	0·45	0·5	0·5	1·1	1·5	..	4·3	10	8½
SM. A51440	R	4·0	0·4	..	0·55	1·35	?1·7	1·45	..	9½	..
SM. A51441	F	3·7	0·5	..	0·65	1·0	1·6	*c.*1·5	..	9	..
SM. A51442	R	3·3	0·4	..	0·5	1·0	*c.*1·35	1·5	..	9	..

Remarks. The geniculum of this subspecies is the most angular of any of the subspecies of *G. tamariscus* and hence comes closest to *Climacograptus*, but there is still some rounding of the geniculum. *Glyptograptus tamariscus angulatus* is close to *G. tamariscus distans*, but differs from it in two respects, the sharper geniculation, and the deeper and longer excavation.

Glyptograptus tamariscus acutus subsp. nov.

Plate 71, fig. 12; text-fig. 3*d*

Number of specimens. One.

Locality and horizon. Rheidol Gorge; *Monograptus gregarius* Zone, horizon H of Sudbury (1958), SM. A24952.

Diagnosis. Narrow (0·5 mm.), parallel-sided, interapertural distance averages 0·9 mm. for the first five thecae. Thecal overlap small, geniculation abrupt proximally becoming gentle distally. Supragenicular wall parallel to sides of rhabdosome. Theca 1[1] has its aperture 0·8 mm. from proximal end of rhabdosome.

Description. The specimen is 6 mm. long and has a uniform width of 0·5 mm. but it is distorted in the region of th1[2]. Below the first pair of thecae the form tapers sharply. The base of theca 1[1] is level with the aperture of the sicula. The length of the sicula is not known since only the reverse side is visible, but here it is exposed for 0·2 mm. before being obscured by th1[2]. The thecae are closely spaced at first (fifteen per centimetre) decreasing to ten per centimetre by the fifth pair of thecae. The supragenicular walls are straight and parallel to the side of the rhabdosome averaging 0·65 mm. long. The geniculation is abrupt at first, but appears to become slightly more flowing distally.

The infragenicular wall is approximately planar. The excavations are moderately deep, occupying half of the width of the rhabdosome, and the apertures are strongly everted.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A24952	R	6	?	0·5	0·5	0·8	1·1	..	3·5	15	10

Remarks. This form is clearly closely related to *G. tamariscus angulatus* and *G. tamariscus varians*. The geniculum is more angular than *G. tamariscus angulatus* proximally, and the thecae are more closely spaced. Like *G. tamariscus varians* the thecae change in shape distally becoming more gently curved, but *G. tamariscus varians* is a much more robust form.

Glyptograptus sp. cf. *G. tamariscus fastigans* Haberfelner

Plate 71, fig. 5; text-fig. 3*f*

1931*a* *Glyptograptus tamariscus* mut *fastigans* Haberfelner, p. 105, pl. 3, figs. 17*a–e*.

Number of specimens. One.

Locality and horizon. Knock, Swindale Beck, immediately downstream from the smash belt between Ashgill shales and Browgill Beds, stratigraphically below locality *c* of Shotton (1935), zone of *Monograptus turriculatus*, *SM.* A51443.

Description. The rhabdosome is wedge-shaped, 5·6 mm. long, tapering evenly throughout and reaching a width of a fraction over 1 mm. at the distal end. The periderm is robust, preserved as a thick, shiny, carbonaceous film. The specimen is partly an obverse view and partly a reverse view. It appears that no septum is present. The proximal end of the rhabdosome is finely pointed leaving the sicula prominent. The sicula is visible in the reverse view for 0·7 mm. before being obscured by th1[2]. The aperture of th1[1] is 1·0 mm. from the proximal end of the rhabdosome and that of th1[2] is 1·2 mm. from the proximal end. The thecae are narrow in the apertural region, with everted apertures. The excavations are long and shallow, of approximately the same depth throughout the rhabdosome (0·15 mm.), thus occupying a much smaller proportion of the width of the rhabdosome distally than proximally. The length of the thecae is difficult to determine; the overlap appears to be at least a third and could be well over a half. The interthecal distance is 0·9 mm. (eleven thecae per centimetre) for th1 to th2 increasing to 1·1 mm. (nine thecae per centimetre) distally.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A51443	F	5·6	0·5	1·05	1·10	1·0	1·25	..	4·1	11	10½

Remarks. This specimen is very similar to *G. tamariscus fastigans*, but differs from it in having its apertures everted rather than introverted, and the thecal overlap in this present specimen could be larger. The horizon of the specimen from Knock is the same as Haberfelner's specimens from the Carnic Alps.

The narrowness of the apertural region of this form and the consequent shallowness of the excavations, makes it doubtful whether it should be referred to *G. tamariscus* at all. It has much in common with *G. elegans* especially in the way that the axial part of the rhabdosome increases distally. The apertures are more restricted than those of *G. elegans*.

Genus CLIMACOGRAPTUS Hall 1865

Climacograptus tamariscoides sp. nov.

Plate 71, fig. 6; text-fig. 3*e*

Holotype. The specimen figured as text-fig. 3*e* and Pl. 71, fig. 6, from horizon C of Sudbury (1958) in the zone of *Monograptus gregarius*, Rheidol Gorge near Aberystwyth, SM. A24924.

Number of specimens. Two.

Localities and horizons. The locality and horizon of the holotype is given above, the other specimen is from Skelgill probably from the *Monograptus argenteus* subzone of the *M. gregarius* Zone BM (NH) H. 1626.

Diagnosis. Short parallel-sided *Climacograptus*, width about 0·7 mm. in relief, geniculation abrupt, slightly less so distally, thecae closely spaced, with average interapertural distance 0·8 mm. (twelve thecae per centimetre).

Description. The holotype is 5 mm. long and attains a width of 0·7 mm. This width is reached by the second pair of thecae, proximally to this the rhabdosome tapers regularly. The obverse view is preserved showing the sicula and a slightly undulating septum. The sicula has an exposed length of 1·2 mm., the top reaching the level of the top of the excavation of th1^2, and a width at the apertural end of 0·15 mm. The base of theca 1^1 extends proximally only as far as the aperture of the sicula. The apertures of thecae 1^1 and 1^2 are 0·75 and 1·15 mm. from the proximal end of the rhabdosome and the average interapertural distance is 0·8 mm. The supragenicular wall is about 0·65 mm. long and slightly convex but generally parallel to the sides of the rhabdosome. The geniculation is abrupt proximally, but becomes gentler distally. The excavations are small giving the thecae the appearance of being restricted in the apertural region. The overlap is of the order of one-fifth.

Dimensions (in millimetres)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*			*th5^1 to th1^1*	*Th/cm.*	
			th1	*th5*	*maximum*	*th1^1*	*th1^2*	*Sicula*		*th1–2*	*th4–5*
SM. A24924	R	5	0·45	0·7	0·7	0·75	1·15	1·2	3·4	12	12

Remarks. This species is clearly related to *Glyptograptus tamariscus*, but differs from it in the abruptness and angularity of the geniculum, it is this feature which suggests reference to the genus *Climacograptus*. Further, the thecae in *C. tamariscoides* are more closely spaced than any form of *G. tamariscus* except *G. tamariscus tamariscus* form B.

Like some of the forms of the latter species the thecal profile changes in shape towards the distal end. It is distinct from other species of *Climacograptus* occurring at the same horizon; *C. hughesi* has very distinctive thecae and a strongly undulating septum, *C. minutus* has a tapering rhabdosome and more closely set thecae, and all the other forms of *Climacograptus* at this horizon are much larger.

Climacograptus tangshanensis linearis subsp. nov.

Plate 72, figs. 2–3; text-figs. 3*g-k*

Holotype. The specimen figured as text-fig. 3*g* from Dobb's Linn in the upper part of the zone of *M. gregarius* probably about the equivalent of horizons A to J of Sudbury (1958) at Rheidol Gorge, SM. A51448.

Number of specimens. Six.

Locality and horizons. All the specimens are from Dobb's Linn from the zone of *M. gregarius.* One specimen (SM. A51444) is from the lower part of the zone, the remainder are from the same horizon as the holotype.

Diagnosis. Climacograptus with short rhabdosome, parallel-sided or gently tapering proximally, proximal end robust, apertures introverted showing a suggestion of an apertural spine.

Description. All the specimens are preserved in very low relief. The longest specimen is 8 mm. in length and is almost parallel-sided; the others are shorter and rather more tapering in form. Nevertheless, the tapering ones are still robust at the proximal end. The proximal end of the rhabdosome is prolonged by a short stout virgella and the proximal extremity of th1[1] is below the aperture of the sicula. The septum appears to be developed only on the obverse side of the rhabdosome. The inter-thecal interval is about 0·75 mm. for the first two pairs of thecae (about thirteen thecae per centimetre) increasing to about 0·85 distally (about 11½ thecae per centimetre). The geniculum is abrupt, formed by the junction of the straight supragenicular wall and the concave infragenicular wall. The supragenicular wall is approximately perpendicular or slightly inclined to the rhabdosome sides. The apertures are very distinctly introverted and the apertural lip is concave so that in some views the aperture seems to extend into a short spine. The excavations are of moderate depth averaging about 0·2 mm. and about the same length, varying only very slightly in size from one end of a rhabdosome to the other. The alternation of the thecae varies; in the holotype they are strongly alternating, but in some other specimens they are sub-opposite. In all specimens the periderm is preserved as a thick, shiny, carbonaceous film, suggesting that it was relatively thick.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A51444	F	8·5	0·65	0·8	0·8	0·9	1·1	..	3·0	14½	11½
SM. A51445	F	5	0·65	0·95	0·95	0·9	1·2	..	3·0	15	12
SM. A51446	F	5	0·65	0·95	0·95	0·9	1·1	..	3·1	15	11½
SM. A51447	F	3·5	0·70	..	0·9	0·9	1·0	..	..	13½	..
SM. A51448	F	6	0·65	0·90	0·95	0·9	1·2	..	3·4	12½	11
SM. A51449	F	4·5	0·65	0·95	0·95	0·8	1·0	1·0	3·0	14½	11½

Remarks. This subspecies seems most closely related to the parent species *Climacograptus tangshanensis* Hsü, described by Hsü (1934) from the Koachiapien shale near Nanking, from the zone of *Monograptus leei* Hsü, which he regards as the equivalent of the zone of *M. gregarius* in the British sequence. *C. tangshanensis* is of the same order of length as the rhabdosome of the present subspecies, which differs principally from the typical form in being narrower (1·0 mm. as against 1·5 mm.) and having its supragenicular walls rather more vertical. It is not clear whether Hsü's specimens have a complete median septum or not. The characters of *C. tangshanensis linearis* are quite different from other described British Silurian climacograptids with the possible exception of *C. scalaris miserabilis*, which has thecae slightly farther apart and horizontal apertural margins.

(*b*) *Wider forms*

Genus GLYPTOGRAPTUS Lapworth 1873

Glyptograptus euodis sp. nov.

Plate 71, figs. 18–22; Plate 72, fig. 1; text-fig. 4*e*, *g-j*

Holotype. The specimen figured as text-fig. 4*g*, Plate 71, fig. 18, from horizon P of Sudbury (1958) of the zone of *Monograptus gregarius* (i.e. near the base of the zone), Rheidol Gorge, near Aberystwyth, SM. A24973.

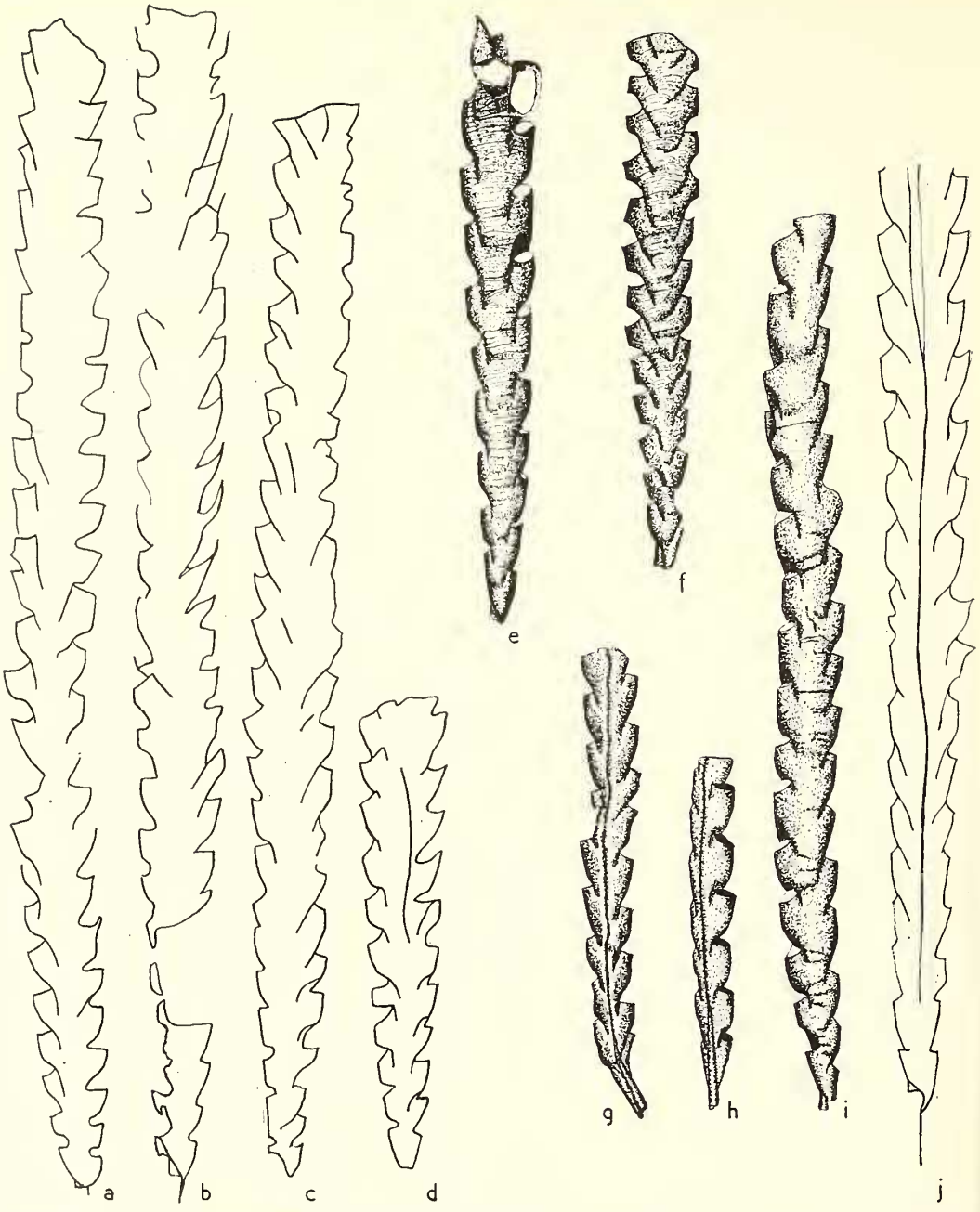
Number of specimens. Eight (both subspecies).

Horizons and localities. Rheidol Gorge, horizons O and P of Sudbury (1958) of the zone of *Monograptus gregarius* (near the base of the zone). Dobb's Linn, horizon unknown.

Diagnosis. Glyptograptid with gently sigmoidally curved thecae overlapping one-third, inclined to the rhabdosome at a low angle, apertures everted strongly, excavations long and of moderate depth, approximately uniformly deep throughout, proximal end of rhabdosome tapered.

Description. Rhabdosomes attain a length of 37 mm. The rhabdosomes widen rapidly for the first few thecae, then remain constant or gradually increase in width up to a maximum of 1·5 mm. in uncompressed specimens. The thecae range in frequency from eight to eleven per centimetre, in the mature portions of specimens. The thecae overlap about a third and have everted apertures. The geniculum is very gentle, occurring rather distally on the specimen so that the thecal excavation is long and open, giving the theca an appearance of being inclined to the rhabdosome length rather than strongly sigmoidally curved. The sicula is long and slender in one form at least, the apex reaches over halfway between th1^1 and th2^1 and is exposed for what is apparently its entire length. The median septum is incomplete, being absent from the reverse side, but complete on the obverse side. If the rhabdosome widens distally then the excavations remain approximately the same depth. Thus, because of the widening of the common canal, the excavations occupy a smaller proportion of the width of the rhabdosome distally.

Remarks. This species can be distinguished from *G. tamariscus* by the more gentle curvature of the thecae, the longer and less definite excavations occupying a smaller proportion of the rhabdosome width, and by a greater overlap of the thecae. *G. incertus* also has thecae with a more pronounced sigmoidal curvature. Apart from their



TEXT-FIG. 4. *a-d. Glyptograptus incertus* Elles and Wood. *a*, Lectotype, reverse of flattened specimen BU. 1274. *b*, Reverse of flattened specimen, SM. A51055. *c*, Reverse of flattened specimen, BU. 1273. *d*, Reverse of flattened specimen, SM. A51454.

e, *G. enodis latus* subsp. nov. Holotype, reverse in relief, SM. A24967.

f, *Climacograptus alternis* sp. nov. Holotype, reverse in relief, SM. A24957.

g-j. Glyptograptus enodis enodis subsp. nov. *g*, Holotype, obverse in relief, SM. A24973. *h*, Obverse in relief, SM. A51450. *i*, Reverse in relief, SM. A51453. *j*, Reverse of flattened specimen, BU. 1271. All figures ×7·5. Horizons and localities given in text.

somewhat wider rhabdosomes and differently shaped thecae, *G. persculptus* and *G. sinuatus* differ from *G. enodis* in having a greater thecal overlap (about a half).

Glyptograptus enodis enodis subsp. nov.

Plate 71, figs. 18–19, 21; Plate 72, fig. 1; text-figs. 4*g-j*

1907 *Diplograptus* (*Glyptograptus*) *tamariscus* Nicholson; Elles and Wood, p. 247, text-fig. 167*d*, pl. 30, fig. 8*b* (*non* text-figs. 167*a-c*, pl. 30, figs. 8*a*, *c*, *d*).

Holotype. The specimen figured as text-fig. 4*g*, and Plate 71, fig. 18, from horizon P (Sudbury 1958) of the zone of *Monograptus gregarius*, Rheidol Gorge, near Aberystwyth, SM. A24973.

Number of specimens. Seven.

Horizons and localities. Rheidol Gorge, the zone of *M. gregarius*. SM. A24973, 51427 from horizon P and SM. 51450-3 from horizon O. Dobb's Linn, horizon unknown, BU.1271 (the specimen figured by Elles and Wood 1907, as *G. tamariscus* in text-fig. 167*d* and plate 30, fig. 8*b*).

Diagnosis. *G. enodis* in which width increases quickly until about the fifth pair of thecae, then parallel-sided or slowly widening.

Description. The longest specimen (Elles and Wood's specimen from Dobb's Linn) attains a length of 37 mm. All the specimens preserved in relief reach their maximum width or very close to it by the fifth pair of thecae. The flattened specimen from Dobb's Linn continues to widen slowly beyond this level. The proximal extremity of the first theca extends slightly beyond the aperture of the sicula, the flattened specimen has a stout virgella. The sicula is long and slender, exposed for its entire length or close to it, and extends distally to about half-way between th1[1] and th2[1]. The thecae have gentle sigmoidal curvature, everted apertures and an overlap of approximately one-third. The supragenicular walls are inclined to the margins of the rhabdosome. The common canal is roughly uniform in width beyond the fifth pair of thecae and occupies about half the width of the rhabdosome in that region and less proximally. The median septum is absent on the reverse side, but complete on the obverse side.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5[1] to th1[1]*	*Th/cm.*	
			th1	*th5*	*maximum*	*th1[1]*	*th1[2]*			*th1–2*	*th4–5*
SM. A24973	R	9	0·5	0·95	1·0	1·1	*c.*1·8	1·7	3·5	*c.*11	10
SM. A51450	R	6·5	0·6	0·9	0·9	1·3	1·5	1·9	3·6	10	10
BU. 1271	F	37	0·65	1·2	1·7	*c.*1·1	*c.*1·2	..	3·7	*c.*10	9½*
SM. A51451	R	3·5	0·65	..	0·95	*c.*1·0	*c.*1·4	..	..	11	..
SM. A51452	R	12	0·65	1·1	1·1	1·1	1·7	..	4·1	10	10
SM. A51427	R	6·5	0·65	1·1	1·1	1·1	1·4	1·4	4·2	10	8½
SM. A51453	R	17	*c.*0·7	1·2	1·3	?1·0	?1·5	..	4·0	11	10*

* Decreasing distally to 9.

Remarks. This form can be distinguished from *G. enodis latus* by its deeper excavations and the different forms of the rhabdosome.

Glyptograptus enodis latus subsp. nov.

Plate 71, fig. 20; text-fig. 4*e*

Holotype. The specimen figured as text-fig. 4*e*, and Plate 71, fig. 20, from horizon O (Sudbury 1958) of the zone of *Monograptus gregarius*, Rheidol Gorge, near Aberystwyth, SM. A24969.

Number of specimens. One (the holotype).

Diagnosis. Long form of *G. enodis*, increases in width throughout its length, common canal widens distally.

Description. The specimen, which is preserved in relief, is 10·8 mm. long, increasing in width throughout its length, reaching a maximum width at the distal end of 1·4 mm. The rhabdosome is sub-rectangular in cross-section. The common canal widens steadily throughout the rhabdosome and occupies a greater proportion of the width distally than proximally. It occupies about half the width at the distal end. The thecae overlap about a third and have a very gentle sigmoidal curvature and everted apertures. The excavations are relatively shallow, they would occupy about a third of the width of the rhabdosome in a full bi-profile view. The length of the sicula is unknown, but its aperture is a little distal to the proximal end of the rhabdosome. The septum is incomplete, it is present at the distal end of the rhabdosome on the obverse side but is absent on the reverse side of the rhabdosome. The specimen shows distinct growth-lines.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A24969	R	10·8	0·65	1·1	1·4	1·0	1·4	..	3·7	11	9

Remarks. Apart from the general resemblance to the typical form, this subspecies has a thecal shape a little reminiscent of *G. sinuatus* and *G. persculptus*, but its thecae are considerably shorter and inclined to the rhabdosome at a smaller angle.

Glyptograptus incertus Elles and Wood

Plate 72, figs. 6–7; text-figs. 4*a-d*

1907 *Diplograptus* (*Glyptograptus*) *tamariscus* var. *incertus* Elles and Wood p. 249, text-fig. 168*a*, *b*, pl. 30, figs. 9*a-d*.

1922 *Diplograptus tamariscus incertus* Elles and Wood; Gortani, p. 104, pl. 17, fig. 24.

Lectotype. The specimen illustrated by Elles and Wood (1907) as plate 30, fig. 9*c*, and figured here as text-fig. 4*a*, and Plate 72, fig. 6, from the Birkhill shale, Garple Linn, near Moffat (*Monograptus sedgwicki* Zone), Birmingham Univ. Coll. 1274.

Number of specimens. About 100.

Horizons and localities. Dobb's Linn: specimens seen from the zones of *M. convolutus* and *M. sedgwicki* (SM. A51055, which was figured by Elles and Wood, 1907, on pl. 30, fig. 9*a*, and SM. A51454 are from the latter zone). Garple Linn; *M. halli* beds (the lectotype, BU. 1274) and horizon unknown (BU. 1273, figured by Elles and Wood, 1907, on pl. 30 fig. 9*b*).

Diagnosis. Robust glyptograptid, essentially parallel-sided with broad proximal end,

thecae with distinct sigmoidal curvature, more pronounced proximally than distally, overlap approximately one-third, eleven thecae per centimetre in the distal part.

Description. Rhabdosomes are normally long, reaching a length of 22 mm. They have blunt, rather than pointed proximal extremities, with a width of 0·6 to 0·8 mm. at the first pair of thecae, widening gradually to about 1·4 mm. at 5 mm. from the proximal end, eventually reaching a maximum of about 1·6 mm. The length of the sicula is unknown, as it is not clearly preserved in any of the specimens examined. It is possible, judging from the shape of the proximal end of the rhabdosome, that only a small proportion of its length was exposed. Normally, there is no evidence of a septum of the specimens, but one or two show some traces, e.g. text-fig. 4*d*. The thecal profile varies throughout the rhabdosome; in the proximal end the sigmoidal curvature is very strong in some specimens, but decreases in intensity towards the distal end of the rhabdosome. This results in a lengthening of the excavation towards the distal end. Overlap is not easy to determine because of the rather poor state of preservation of the specimens, but it appears to be generally of the order of a third, though in some it could be as high as a half. The interthecal interval is about 0·7 mm. between the first two thecae (about fourteen thecae per centimetre) but increases over the interval in which the width increases rapidly, to 0·9 mm. between the apertures (eleven thecae per centimetre). The excavations are deeper distally, but considerably longer, and occupy a smaller proportion of the width of the rhabdosome (a half or more at the proximal end, and a little over a third at the distal end). The apertures are horizontal or slightly everted and the supra-genicular walls are inclined to the rhabdosome margin. The periderm is moderately thick.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of Rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A51055	F	22·5	*c.*0·8	*c.*1·2	1·6	0·6	?0·6	..	?	?	?
BU. 1273	F	20·5	0·6	1·2	1·7	?	?	..	2·8	15	11
BU. 1274	F	23	0·8	1·3	1·7	0·6	0·8	..	2·9	15	11
SM. A51454	F	9·8	0·6	1·3	1·7	0·6	0·9	..	2·8	14	12

Remarks. This species is very distinctive. Comparison with *Glyptograptus tamariscus* reveals sufficient points of difference to warrant its being regarded as a separate species, and Elles (1922) apparently regarded it as a separate species rather than a variety of *G. tamariscus*, since it is cited as such in the table accompanying that paper. The shape and size of the rhabdosome, the change in thecal interval and thecal shape are all distinctive characters, distinguishing it from not only *G. tamariscus*, but other species of *Glyptograptus*. It is also distinct from *Mesograptus* because the proximal thecae of *G. incertus* are never truly amplexoid, nor are the distal thecae truly orthograptid.

Glyptograptus elegans sp. nov.

Plate 72, figs. 4, 10–12; text-figs. 5*a-i*

1920 *Diplograptus tamariscus incertus* Elles and Wood; Gortani, p. 18, pl. 1, fig. 24 (*non* figs. 25–27).

1922 *Diplograptus tamariscus* Nicholson; Gortani, p. 105, pl. 17, fig. 25.

Holotype. The specimen figured here as text-fig. 5*c*, and Plate 72, fig. 12, from the zone of *Monograptus sedgwicki*, Dobb's Linn, near Moffat, SM. A51455.

Number of specimens. Ten.

Horizons and localties. Dobb's Linn: lower part of the zone of *M. gregarius* (SM. A51416), zone of *M. convolutus* (SM. A51458), zone of *M. sedgwicki* (SM. A51455, SM. A51456, SM. A51459, SM. A20411). Knock; Swindale Beck, immediately downstream from the smash belt between the Ashgill shales and the Browgill beds, stratigraphically below locality C. of Shotton (1935), zone of *M. turriculatus* (SM. A51457). Torver Beck; zone of *M. sedgwicki* (SM. A20386a, b). Rheidol Gorge; zone of *M. gregarius* D horizon (SM. A24933 doubtfully referred to this species).

Diagnosis. *Glyptograptus* with rhabdosome tapering to a fine point proximally, may reach its maximum width in as little as 5 mm., thecae considerably more sigmoidally curved proximally than distally.

Description. The rhabdosomes are normally short, 8 mm. or so in length, reaching a maximum length of 15 mm. They widen gradually over the first 5 millimetres of their length to about 1 mm., from a width of about 0·5 mm. at the first pair of thecae. Proximal to the first pair of thecae, the rhabdosome is finely tapered; this feature is more apparent in flattened specimens, in which the sicula is evident in both obverse and reverse views. Distally, the rhabdosome either continues to widen throughout its length or else becomes parallel-sided. The maximum width observed is 1·4 in an uncompressed specimen. The sicula is quite prominent and has an exposed length of 1 millimetre. About half the specimens show some trace of a septum, but one specimen (Text-fig. 6*a*), although well preserved, shows no trace of a septum on the obverse side. The thecal profile is strongly sigmoidal at the proximal end, with narrow and often deep excavations. In this region the supragenicular walls are parallel to the sides of the rhabdosome. Distally the sigmoidal curvature is only moderate, the excavations are longer, more open and a little deeper, and the supragenicular walls are inclined gently to the margins of the rhabdosome. The overlap appears to be of the order of a third. The thecal interval decreases slightly from the proximal to the distal end; between the fourth and the fifth thecae it is between ten and twelve per centimetre. The apertures are everted. The periderm appears to have been of moderate thickness.

EXPLANATION OF PLATE 72

All figures × 7·5. Horizons and localities given in text.

Fig. 1. *Glyptograptus enodis enodis* subsp. nov.; BU. 1271, distal thecae of flattened specimen.

Figs. 2–3. *Clinacograptus tangshanensis linearis* subsp. nov. 2, SM. A51446, obverse of flattened specimen. 3, SM. A51444, impression of reverse of flattened specimen.

Fig. 4. *Glyptograptus elegans* sp. nov. SM. A51457, obverse of flattened specimen.

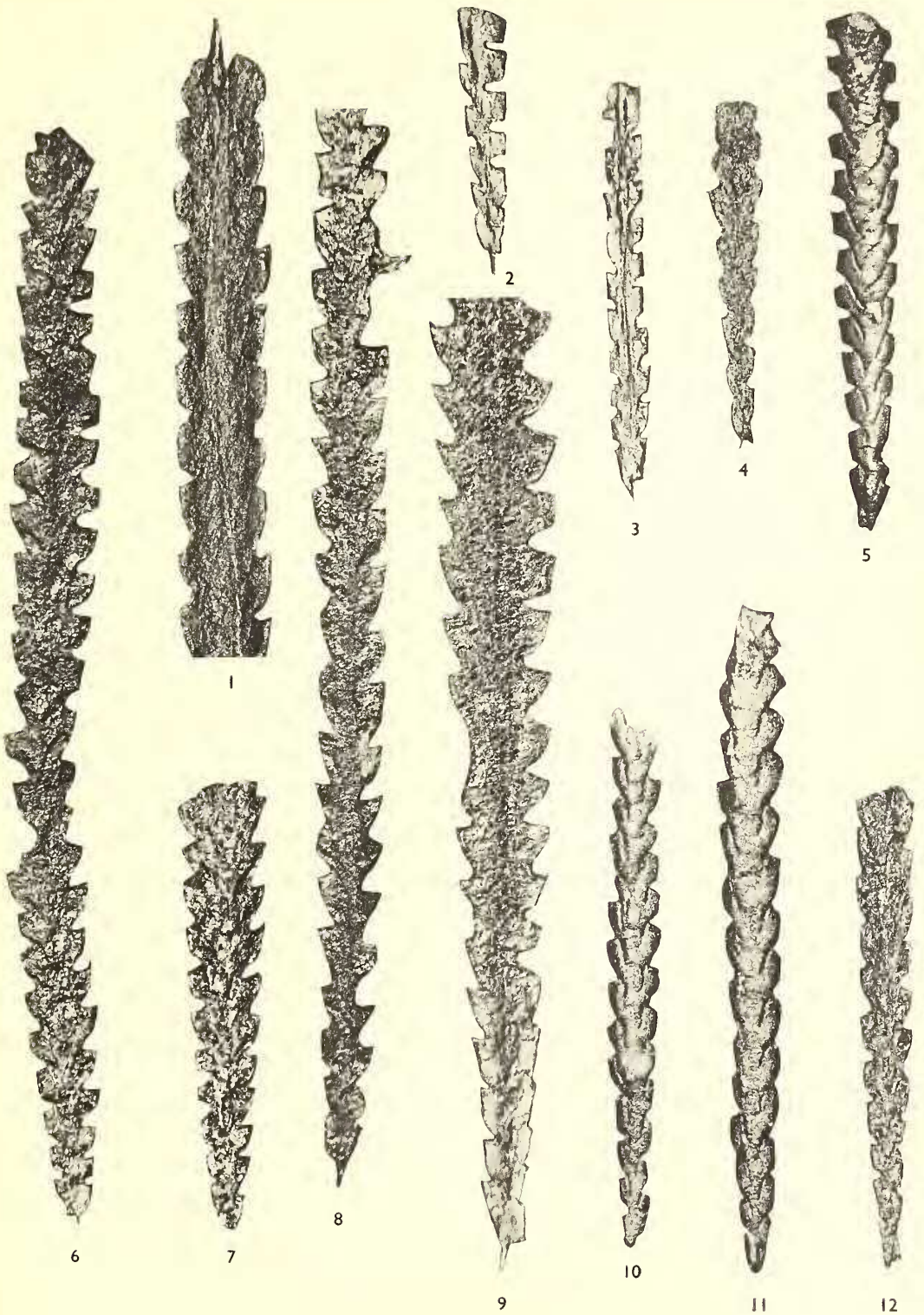
Fig. 5. *Clinacograptus alternis* sp. nov. SM. A24957, holotype, reverse in relief.

Fig. 6–7. *Glyptograptus incertus* Elles and Wood. 6, BU. 1274, lectotype, reverse of flattened specimen. 7, SM. A51454, reverse of flattened specimen.

Fig. 8. *Glyptograptus tamariscus linearis* Perner; BM 1272, Reverse of flattened specimen.

Fig. 9. *Glyptograptus serratus* Elles and Wood; SM. A20388*b*, reverse of flattened specimen, counterpart of specimen figured by Elles and Wood (1907) as text-fig. 169, Belcraig Burn, zone of *Monograptus sedgwicki*.

Figs. 10–12. *Glyptograptus elegans* sp. nov. 10, SM. A20386*a*, ? reverse of specimen in relief. 11, SM. A20386*b*, obverse in relief, specimen lacking septum. 12, SM. A51455, holotype, obverse of flattened specimen.



PACKHAM, Lower Silurian diplograptids

Dimensions (in millimetres)

Specimen Number	Flat or relief	Length of Rhabdosome	Width			Length		Sicula	$th5^1$ to $th1^1$	Th/cm.	
			*th*1	*th*5	maximum	$th1^1$	$th1^2$			*th*1–2	*th*4–5
SM. A51416	F	6	0·5	1·0	1·0	1·0	1·4	..	3·4	12	11
SM. A51455	F	10	0·5	1·0	1·1	0·9	1·4	?1·0	3·1	11	11
SM. A51456	F	4	0·5	*c.*1·0	1·0	0·7	1·0	..	3·1	14	12
SM. A51457	F	7·3	0·5	0·85	*c.*1·1	0·7	1·0	..	3·2	?13	11
SM. A51458	F	..	0·6	1·1	1·5	0·7	0·95	..	3·2	..	..
SM. A51459	F	6·8	0·5	1·0	1·2	1·0	1·2	..	3·0	..	12
SM. A20411	F	8·5	0·6	0·9	1·0	0·9	1·2	0·9	*c.*3·3	12	11
SM. A20386*a*	R	10·8	?0·5	?0·95	1·0	?0·7	?1·1	..	3·2	14	12
SM. A20386*b*	R	13·5	0·4	0·9	1·4	0·7	1·0	..	3·3	*c.*14	*c.*10
SM. A24933	R	15·2	0·6	0·9	1·3	1·1	1·5	..	3·6	12	10

Remarks. This species has some affinity with *G. incertus* and *G. enodis enodis*. It differs from the former in having a narrower proximal end, and from the latter in having thecae which vary along the rhabdosome length. A detailed comparison of the descriptions of the three forms will reveal a number of less striking differences.

Genus CLIMACOGRAPTUS Hall 1865

Climacograptus alternis sp. nov.

Plate 72, fig. 5; text-fig. 4*f*

Holotype. The specimen figured as text-fig. 4*f*, and Plate 72, fig. 5, from horizon J (Sudbury 1958) of the zone of *Monograptus gregarius*, Rheidol Gorge, near Aberystwyth, SM. A24957.

Number of specimens. One (the holotype).

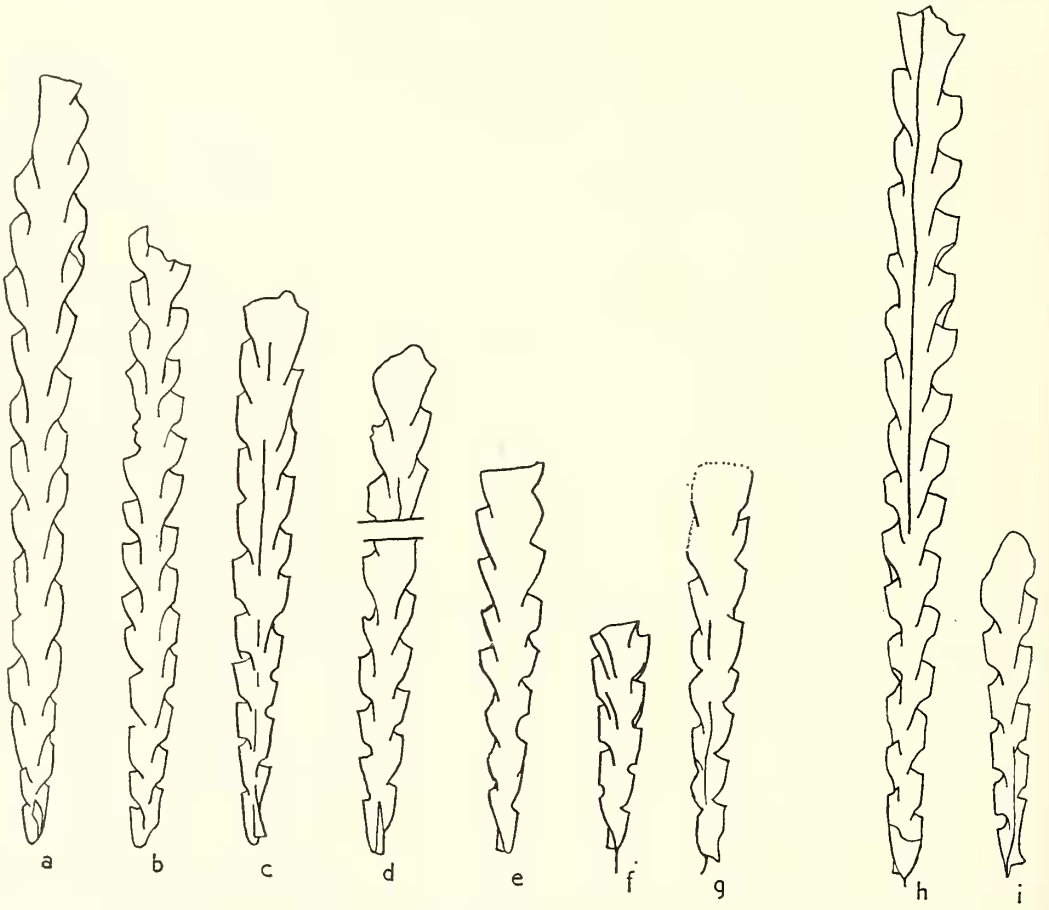
Diagnosis. Climacograptus with a narrow proximal end attaining a width of about 1·4 mm. at 1 cm. from the proximal end (specimen in relief), about fourteen thecae per centimetre throughout the rhabdosome, excavations becoming longer in proportion to their depth distally.

Description. The specimen is 10·4 mm. long, widening gradually over the first 5 millimetres and thereafter is nearly parallel-sided. The obverse side of the specimen is displayed and at the proximal end, the base of $th1^1$ is relatively restricted, as also is the proximal end of $th1^2$; thus the sicula is prominent even on the obverse side. The sicula is visible for nearly half a millimetre before being totally obscured by $th1^2$. There is no septum on the obverse side of the rhabdosome. The appearance of the thecae changes throughout the rhabdosome. At the proximal end the excavations are shorter than distally. The supragenicular walls of the proximal thecae are inclined to the rhabdosome margins distally. They are in general parallel to the rhabdosome margin, but are somewhat variable. The length of the supragenicular wall decreases slightly distally so that the excavations become longer in proportion to their depth towards the distal end. The apertures are everted throughout. The overlap of the thecae is a little over a third. The interthecal septa are inclined at about 25° to the rhabdosome axis. The appearance of the outer surface of the rhabdosome is unknown. The type specimen is an internal

cast in pyrite. Prominent but rather irregular growthlines are apparent, particularly at the axial part of the rhabdosome.

Dimensions (*in millimetres*)

Specimen Number	*Flat or relief*	*Length of Rhabdosome*	*Width*			*Length*		*Sicula*	*th5*[1] *to th1*[1]	*Th/cm.*	
			th1	*th5*	*maximum*	*th1*[1]	*th1*[2]			*th1–2*	*th4–5*
SM. A24957	R	10·4	0·75	1·2	1·4	0·75	1·2	..	3·0	14	13½



TEXT-FIG. 5. *a-i*, *Glyptograptus elegans* sp. nov. *a*, Obverse in relief lacking sicula and septum SM. A20836*b*. *b*, ? Reverse in relief, SM. A20386*a*. *c*, Holotype, obverse of flattened specimen, SM. A51455. *d*, Obverse of flattened specimen SM. A20411*b*. *e*, Reverse of flattened specimen, SM. A51459. *f*, Reverse of flattened specimen, SM. A51456. *g*, Obverse of flattened specimen, SM. A51457. *h*, Reverse of specimen in relief doubtfully referred to this species, SM. A24933. *i*, Obverse of flattened specimen, SM. A51416.
All figures × 7·5. Horizons and localities given in text.